



MINISTERIO DE INDUSTRIA  
JUNTA DE ENERGIA NUCLEAR

Madrid, November 30, 1976

Dr. H. D. Bruner, M. D.  
Medical Science Advisor  
Division of Biomedical and  
Environmental Research  
Energy Research and Development Administration  
Washington D. C. 20.545

Dear Dr. Bruner:

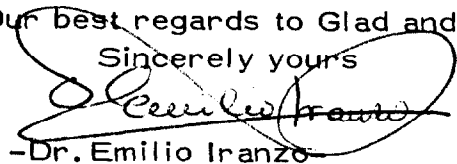
I have the pleasure of sending to you the report on the plans for the present year's work on the Indalo Project. At the same time and by air mail also I send to Dr. Minthorn the same report. I hope it will not arrive too late.

As you can see in the summary about vegetation, we have found some important contamination in the cultivated tomatos around the O point of number 2.

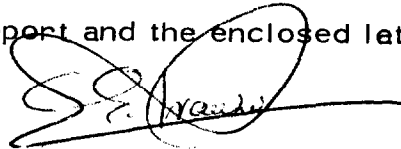
We are working so far in the recopilation of all the data to write several reports, as we were discussing.

Los Santos arrived from his trip very satisfied with the discussions with all the persons he met and the attentions they had to him.

Our best regards to Glad and you from all of us  
Sincerely yours

  
-Dr. Emilio Iranzo-  
Jefe de Protección y Medicina

NOTE: Because I have not the right addres of Dr. Minthorn please give to him the other copy of the report and the enclosed latter.



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MINISTERIO DE INDUSTRIA  
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Madrid, November 30, 1976

Dear Dr. Minthorn:

I have the pleasure of sending to you a summary report on the work has been made so far for Indalo Project, including the plans we have for the next year. I hope this will be sufficient to certify the fund for the actual fiscal year. As you can see from the budget the cost of the Project in 1976 has been very high in relation with the amount we get from you. So if it is possible it would be desirable to increase it as it is ask for in the report.

Sincerely yours

-Dr. Emilio Iranzo-  
Jefe de Protección y Medicina

DOE ARCHIVES

Covering letter stating inclosure is a submission for continuing assistance for the next fiscal year (October 1976 to September 30 1977)

TITLE : PROYECTO INDALO. Following of the effects of the accident at Palomares, Spain, from 1966.

#### 1.- INTRODUCTION. -

Two nuclear weapons accidentally dropped from a burning B-52 went into one-part disruptive explosion spreading <sup>239</sup>Pu over areas of farmland and houses at Palomares, located close to the sea in the province of Almeria, South -East of Spain.

Joint clean up by United States Air forces and Junta de Energia Nuclear was made by removal of most contaminated soil, deep plowed and wetted and fields restored.

Wright Langham helped us to set up a surveillance program which had formalized under the Otero-Hall agreement signed in Madrid in March 1966.

The agreement covers surveillance and sampling of air, soils, vegetation and the people who lived in Palomares at the time. Lately people who were not closely affected by the burst have requested and been supplied with the personal surveillance and monitoring afforded those most affected.

#### **DOE ARCHIVES**

The procedures in the Agreement which have been carried out with the support of the A E C include counting equipment, alpha spectrometers,

whole body and lung counters and miscellaneous special supplies. Because of the naturally high alpha background of the area alpha spectrometry is required and the rate of carrying out the chemical and radiometric analyses of samples has been correspondingly slow.

The lung counter has not functioned in a reliable manner until recently, Mr Phil Dean has been of great assistance here. Urine specimens from the 78 people most affected have therefore served for the best estimate of whole body content of  $^{239}\text{Pu}$ . We have hoped to get data from the lung counter that would certify or agree with the urine data and viceversa but this still has not been achieved (see below).

For obvious reasons the people have to be brought from Palomares to the counter which is situated on the grounds of the Centro de Energia Nuclear "Juan Vigón" adjacent to the Medical and Health Physics Building. This is the most expensive part of the surveillance, but estimates of personnel contamination are the most important in our view. Unfortunately they have not been obtained definitively as yet. We recognize that counting accurately in the range of less than 16 nanocurie of  $^{239}\text{Pu}$  is close to the limit of the technique. With Mr. Dean's help we hope to achieve this reliability.

Without the chest counts we have no way of estimating whether the people living as farmers on the low contaminated soil have inhaled resuspended  $^{239}\text{Pu}$  on agricultural dust or otherwise.

**DOE ARCHIVES**

By other way we should like to note that many of these people show lung counting rates that are of low reliability and we are caught in the logic of selecting the count of one person as being reliable and that of another not when both live under similar circumstances. We wish to be assured of the reliability of their lung counting procedures or else put our confidence solely on urinary excretion as the criterion for their internal contamination.

## 1. - SUMMARY OF CURRENT RESULTS.

### AIR

A network of aerosoles sampling was set up in order to discover what possibilities there might be of internal contamination of the people who live in the zone and cultivate the fields, as an isolated or related consequence of the ploughing operations on the ground and the climatological characteristics of the zone, especially those related to the low rainfall and prevailing winds. The airborne sampling was established in June 1966.

This network consisted of four sampling stations, and two for the study of the speed and direction of the winds. The samples stations were situated in the places nominated S-1, S-2, P and 3-1, which respectively correspond to the zones where the two fragmented bombs fell, and one point at the urban centre of Palomares. Those for measuring the characteristics of the winds were situated at S-1 and P. In each one of these stations, at a height of 1.70 m, continuous 24-hour samples are taken, with a volume of approximately  $95 \text{ m}^3$ , every day of the year, on membrane filter paper. The samples are prepared for sending to the laboratories of the Medicine and Protection Division of JEN, where in principle, a minimum of one week after they were taken, a count was made of the total alfa activity due to radioactive elements with a long half life.

In September 1969 the network was reduced to the sampling stations S-2 and P and to the meteorological station P. **DOE ARCHIVES**

The following conclusions may be drawn from the analysis of the results.

- The elimination of the radionuclides contaminating the surface layer of soil, and their dilution in the subsoil to a depth of 25 cm., has
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proven effective in reducing the mean values for radionuclide concentration in the air to levels consistently below the permissible maxima.

- During the first years on very few occasions was the daily concentration of radionuclides in the air higher than the maximum permissible value, and on all of those occasions, the wind velocity fluctuated between 17 and 64 km/hr.
- The combined action of the weather conditions and farming of the soil have resulted in the resuspension of particles of plutonium and uranium oxides in the air, although the concentration of these radionuclides in the air has consistently remained well below the maximum permissible concentrations for these elements, in the insoluble form in which they are found in the area of the accident.
- The incidence of the presence of uranium in the air was higher than that plutonium, for 30% of the samples analyzed showed no trace of plutonium, as compared with 30% which contained no uranium.
- In the zone containing the town, the airborne concentrations of plutonium and uranium have remained far below the ones in other areas where larger concentrations of these elements were mixed into the soil to a depth of 25 cm.

#### **DOE ARCHIVES**

- The values for 1967 were lower than the ones for 1966, with the exception of the concentration of plutonium -239 in area 2-2, which increased significantly in 1967. From 1969 the concentrations were decreasing and in the last years and from time

to time some samples give results in the order of  $10^{-16} \mu\text{Ci}/\text{cm}^3$ . Most of the samples are giving results which are under the detection limit, which is  $5 \times 10^{-17} \mu\text{Ci}/\text{cm}^3$ .

### SOILS

The contamination of the soil surface was not homogeneous. In order to determine the degree of distribution, and what this distribution was on the surface, as well as its depth, after the operations of decontamination, and those planned to eliminate surface contamination in areas required, a study was planned in order to find out which these were and to permit us, as years go by, to discover the dynamics of plutonium-239 in cultivated land, both as regards its dynamics parameters and those introduced by tilling and cultivation methods.

For this purpose, six areas were chosen of 50 m<sup>2</sup> each, two from each of the 3 zones into which the total contaminated area was divided, corresponding to the two areas where the bombs fell and broke. These areas were chosen in places which had remained most contaminated after the removal of a layer of earth on the areas which had contaminations higher than 700,000 d.p.m./100 cm<sup>2</sup>. Those in zones 2 and 3 comprise areas where total alpha contaminations were found to be between 700,000 d.p.m./100 cm<sup>2</sup>; area 2-1 belongs to a part where the upper layer of earth was also removed during decontamination operations. The areas in zone 5 showed contaminations of the order of 70,000 - 7,000 d.p.m./100 cm<sup>2</sup>.

**DOE ARCHIVES**

In order to find the average background of total alpha activity on the ground of the zone, two similar areas were chosen, with similar geological characteristics and situated at 1,000 m. and 7,000 respectively from the zero line of the contaminated zone.

In each of the areas, and in accordance with its diagonals, during the first year, 1966, nine samples were taken which were divided into fragments, corresponding to depths of 0-5, 5-15, 15-25, 25-35 and 35-45 cm. Of the homogenised samples corresponding to each fragment, two fractions of 0.50 gm. were taken, which were submitted to chemical treatment and alfa counting, in order to determine the total alfa activity.

Same type of samples have been taking during 1967, 1969, 1971, 1972, 1975 and 1976 at points in the same areas and following a preplanned distribution order in order to obtain complete knowledge of the dynamics of the contamination, as well as to deduce the contamination factors of the vegetable products which are cultivated in them. In 1969, 1972, 1973, 1975 and 1976 it has been made a separate sampling of the surface of the soil.

In these samples, we are determining the Pu-239 content by radiochemical separation and alpha spectrometry.

From the results obtained so far it may be deduced:

- 1). - In 1966 in zone 2-1, where a 5 cm. layer of soil was removed, the remaining contamination was nil. During the following years it has been found Pu-239 surface contamination transported maybe by winds or by rain water.
- 2). - As a result of ploughing and breaking up of the ground, a distribution of contaminating elements have been obtained to a depth of 30 cm. Generally highest contamination levels are found in layers between 15 and 25 cm. down.

#### **DOE ARCHIVES**

- 3). - The maximum average value of Pu-239 concentration found in the areas studied is in the order of  $6 \times 10^{-3}$  pCi/gr.



The unhomogeneous distribution of the contaminating particles, even after the ploughing operations carried out, is perfectly clear from the values obtained, as might logically have been expected. Even results from different samples from the same point and fragment, after the greatest homogenisation possible in the laboratory, show quite a considerable dispersion.

### VEGETATION

The work carried out with vegetables has tended to determine the possibilities of their external contamination, as a consequence of their cultivation in contaminated and surrounding areas, and to the study of the plants' absorption capacity, and its settling on fruits and seeds.

For the purpose, in each one of the areas previously mentioned, and in the places where the soil samples are taken, samples have been taken of the existing crops. Not all the areas have been cultivated every year and for this reason it was not possible to take samples from some areas in some years. In area 2-1, and given that it was part of an uncultivated plot, of which the upper layer of soil had been carefully removed, making sure not to destroy the existing vegetation, the tomato plant samples were taken from nearby strips of cultivated land where the upper layer of soil had not been removed; the same type of sampling it has been made to get wild plants of the area.

### **DOE ARCHIVES**

From the alpha spectrometry results to determine the Pu-239 contents the following deductions could be made:

- The plants cultivated on contaminated soils shows a Pu-239 contamination.
- Tomatos, beans, barley and maize are the most cultivated vegetation in the area. Most of the contamination by Pu-239 has been in the plant itself and very little in the fruits and seeds.
- The greatest degree of contamination found has been in wild plants (asparagus, esparto grass and other graminaceous plants) which grow in the proximity of the area 2-1.
- The degree of contamination has been decreasing along the years in cultivated and wild plants. The last years the contamination by Pu-239 has been sporadic in the cultivated plants.
- Tomato plants cultivated in 1976 in the proximity of the point where the bomb nº 2 fell down shows important Pu-239 contamination.

### PERSONS

The study of the determination of possible internal contamination of the people of Palomares, both in the case of those who went there afterwards, and especially those who walked through contaminated areas during the first moments, was planned under the following two aspects:

- 1). - Determination of the Plutonium-239 excreted in urine, in order to determine the fraction which could have passed the pulmonary and lymphatic limit.
- 2). - Determination of the quantity of plutonium-239 present in the lungs.

**DOE ARCHIVES**

To obtain this information, after the analysis of plutonium-239 and total alfa activity in urine had been carried out soon after the accident, on the persons who at that time were considered those most likely to have been internally contaminated, a selection was made from the people of Palomares, with respect to the following considerations:

- 1). - Situation nearest to the points of impact of the fractional bombs, and the areas of greatest contamination at the moment when the accident occurred, therefore with the greatest possibilities of inhaling the aerosol created in the conventional explosions.
- 2). - Stay in zones of highest contamination during the day of the accident and the following day.
- 3). - Residence, at the time of the accident and the days following it, in houses and areas of the town where a higher contamination had been found, within the lower limits where contamination was produced in the town, as may be seen from the plan of the contaminated area.
- 4). - Situation during the accident and following it, in houses and areas of the town where contamination was nil, so that they could serve as controls, and at the same time we could find out with certainty whether a mistake had been made in not considering evacuation of the people of that area as necessary in the operations of contamination limit fixing and decontamination.

#### **DOE ARCHIVES**

Taking the above factors into account, a total number of 100 persons were selected, of which 49 were males over 14 years, and 9 were females under 14 years.

They were taken to Madrid for the said tests to be carried out in the laboratories of the Division de Protección y Medicina de la Junta de Energia Nuclear. They first underwent a complete medical examination, in order to find out their state of health and take it into account in the study and subsequent epidemiological control.

In order to determine the concentration of plutonium-239 excreted in urine, three complete 24-hour samples of urine were taken from each one of the said persons, on three consecutive days. These samples were submitted to a chemical treatment in order to determine the content of the said element, by alfa spectrometry, on the final electrodeposit following a separation by ion exchange resins.

The result of this analysis showed that in 71 per cent of cases there was no indication of the existence of plutonium-239, 18 per cent showed, in some analyses, contents of less than, 0.1 disintegrations per minute in the urine of 24 hours, 9 per cent showed contents of between 0.2 and 0.1 disintegrations per minute over 24 hours, and finally, 2 per cent showed a content of between 0.2 and 1 d.p.m. in the urine of 24 hours.

Bearing in mind what these values represent on the alfa spectrum corresponding to the 1000-minute measurements taken, we have taken a deliberately pessimistic view, although in almost all cases they could be considered negative.

#### DOE ARCHIVES

In order to determine the pulmonary content of plutonium-239, measurements were taken on all the previously-mentioned persons, with proportional pulmonary counters, considering the region between 10 KeV-28 KeV, where the XL rays of uranium are found of 13.6, 17.4 and 20.2 KeV in an abundance of 4% por desintegration. These counters consist of two gas flow proportional chambers, with a capacity of 14 litres and a sensitive detection surface of 17.4 x 30.1 cm each, which work with a mixture

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of argon (90%) and methane (10%) and which have been designed in the Los Alamos National Laboratory" by Mr. P. Dean. The calibration of the said chambers was effected with a point source of plutonium-239, and two sheets of methyl metacrylate 2.54 cm thick to simulate the tissues of the thorax.

Taking into account the background of the chambers, the counting time and their efficiency, it was found that the minimum detectable value of plutonium-239 was  $40 \times 10^{-9}$  Ci. In the test made under these conditions, all the values obtained were on the order of background.

In consequence of the technological developing in the field of whole body and lung counters a new scintillation equipment designed by Mr. P. Dean, substituted the gas flow proportional chambers to determine the pulmonary content of plutonium-239. To determine the lung contamination in persons with the new equipment and to determine the concentration of plutonium-239 excreted in urine, 57 persons from Palomares were taken to Madrid in 1974-1975. Because the results obtained were not of much confidence due to the conditions of the lung counter equipment some arrangements were made. In 1976 again 132 persons have been taken to Madrid.

From the results obtained so far we can do the following considerations:

- Few urine samples have given plutonium-239 content.
- Several people looks like they have plutonium-239 contamination in the lungs.
- There is not a close relation between urine contamination and lung counting.

**DOE ARCHIVES**

- In no person has been obtained a very clear and definitive peak in the region of 16 KeV to determine a high contamination.
- We are not yet in conditions to formulate a statement about this very important question.

#### CROMOSOMIC ANALYSIS

Every persons from Palomares wich is submitted to personal monitoring it is submitted to medical and clinical examination.

Furthermore of the usual analysis we make a cromosomic analysis. So far it has been made this type of analysis to 123 persona and we are investigating the results.

**DOE ARCHIVES**

3. - PLANS FOR FIRST OCTOBER 1976 to SEPTEMBER 30, 1977

1. - Send Dr de los Santos to visit the counting equipment and analitic laboratories at the "Health and Safety Laboratory", at "Lawrence Livermore Laboratory " and at "Los Alamos Scientific Laboratory"

Dr de los Santos speaks English writte well and is incharge of the lungs counting procedures.

2. - Continue to sample the air, vegetation and surface soil as before.

3. - Surface monitoring of all the area.

4. - Continue to bring people from Palomares for whole body and lung counting plutonium-239 urine excretion determination, medical examination and clinical and cromosomic analysis.

The people who live there, about 1500, have become more sophisticated about what occurred and some hundreds have asked to be counted over and above the 78 people that were in the original sample.

We are at a loss to say no to them under the circunstances.

**DOE ARCHIVES**

5. - During this time we propose to gather all our data with the prospect of interpreting them and puting them in a form suitable for publication. We propose to write an overrall summary first stating the plan of the data collection relating to the contaminating event and giving the results with reference to the methodologies. The observations on the air and water, soil, vegetation and the inhabitants could be treated in separate paper as there are much data in each

collection that should be mentioned. We also want to make very clear the limitations of our data, the importance of the background from alpha emitters and the confidence that we place in the work.

We wish to take every precaution against being misquoted or lowering the data used out context.

On that basis we will propose whether the program shall be continued or modified.

6. - The development of leukemia in two persons, children in the time of the accident (who may or may not have been contaminated) suggest at this point the possible need for some kind of a medical surveillance of the population to keep a watch for diseases or deaths that may occur over the next 10 years or so. We shall be looking for unusual diseases or abnormal frequency of a disease. The problem of control data here is difficult because Spain does not have a cause of death reporting system. It would not be advisable to attempt an epidemiological study because the people in Palomares would not cooperate maybe.

#### **DOE ARCHIVES**

7. - Dr. E. Iranzo will go to USA to discuss all the results obtained so far.



## B U D G E T

The cost of all the work made for Proyecto Indalo during 1976 has been the following:

People and installations at Palomares .....	578 840 Ptas/year
Soils and vegetation sampling .....	674 182 Ptas/year
Trips for conversations and inspections at Palomares by the responsables of the Program ..	190 440 Ptas/year
Airborne, soil vegetation and urine analysis for plutonium determination .....	2 962 876 Ptas/year
Traveling cost for people from Palomares (10.333/person ) .....	1 363 956 Ptas/year
Medical, clinical and cromosomic analysis for people from Palomares (20.885/person )	2 756 820 Ptas /year
Lung and whole body counting (1.777/person )	234 464 Ptas/year

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T o t a l       .....       8 761 578 Ptas/year

**DOE ARCHIVES**

The amount we will need for October 1976 to September 1977 will be higher because the increase in the price of everything including the salaries.

So we estimate that a budget of approximately 5 million of pesetas could be a good contribution from you because it represents about half of the total cost.

FINAL NOTE

In the last visit of Dr. H. D. Bruner he brought us the draft of EPA's proposed limits for soil contamination and we believe most of Palomares is within these limits except some spots, and specially the area where bomb nº 2 fell down, where it was impossible to clean the rocky surface and rains have washed the residue to the bottom of the notch between the low rocks.

**DOE ARCHIVES**